

# Design Issues for High Temperature Electronics

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*Workshop on Extreme Environmental  
Technologies For Space Environments  
- Jet Propulsion Laboratory  
- California Institute of Technology*

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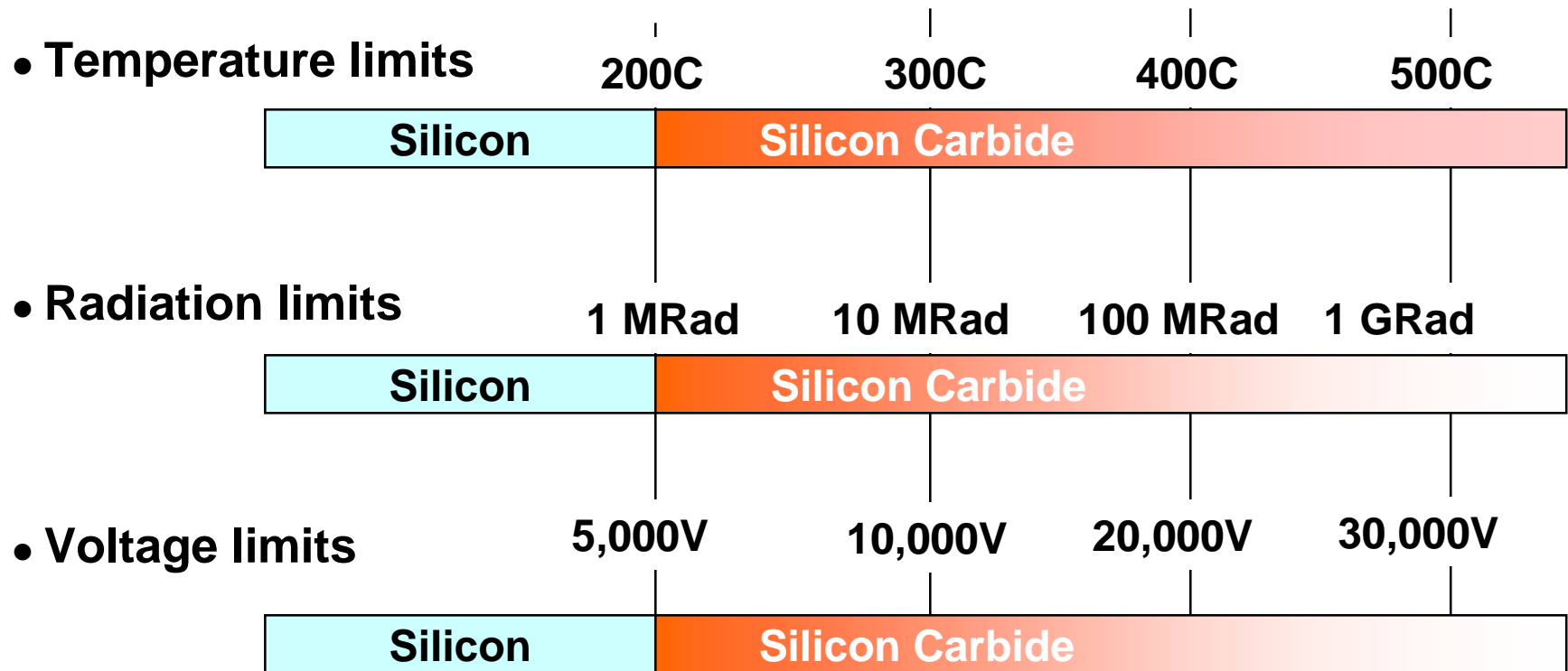
# Design Issues for High Temperature

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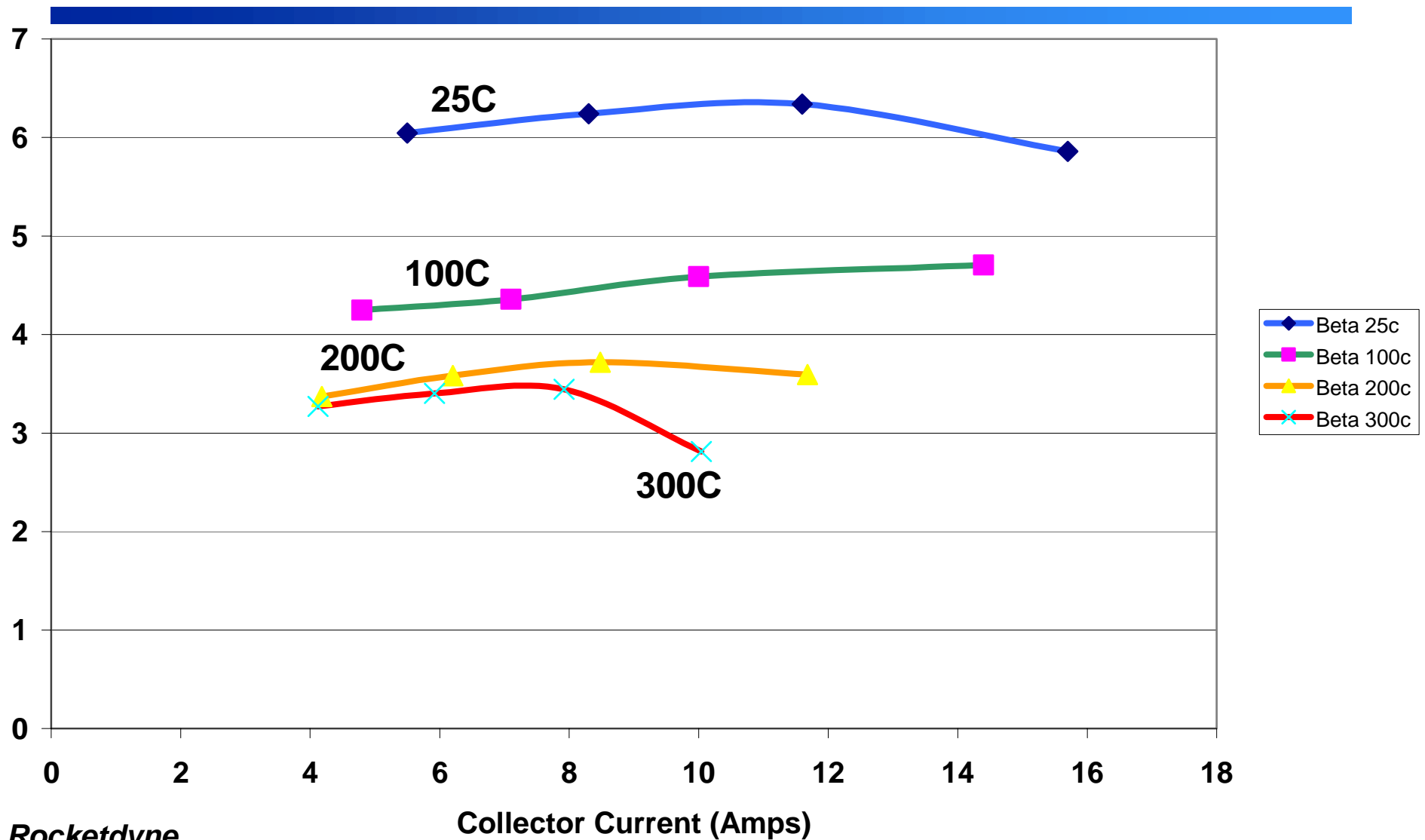
## Component Technologies for High Temperature

- Switching devices
- Linear devices
- Magnetics
- Capacitors
- Resistors
- Printed Circuit Board
- Solder
- Wires
- Connectors

# Switching Devices



# Temperature Tests of SiC BJT



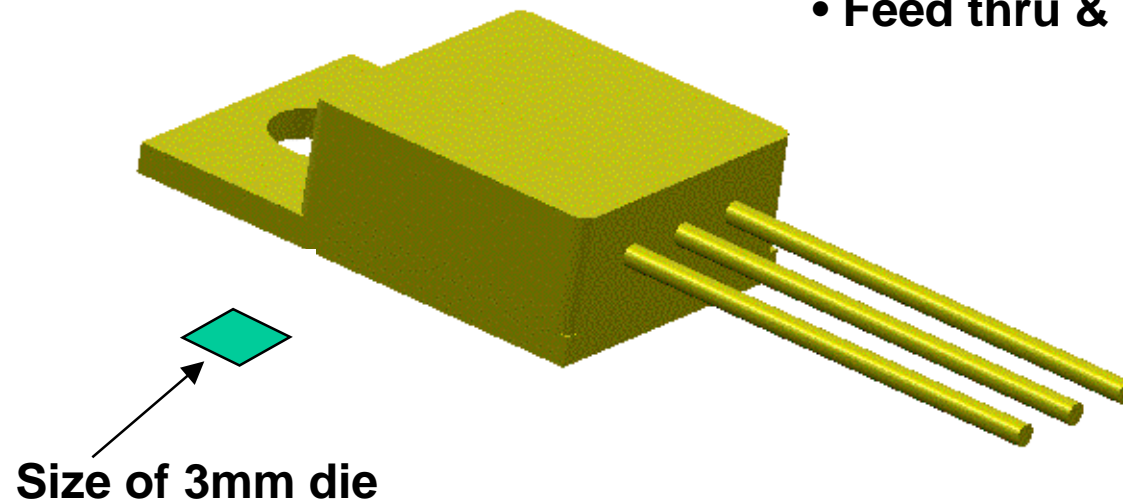
# High Temperature Packaging

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Common device package  
T0-257

## Package Issues

- Package size
- Voltage limits
  - Feed thru & die

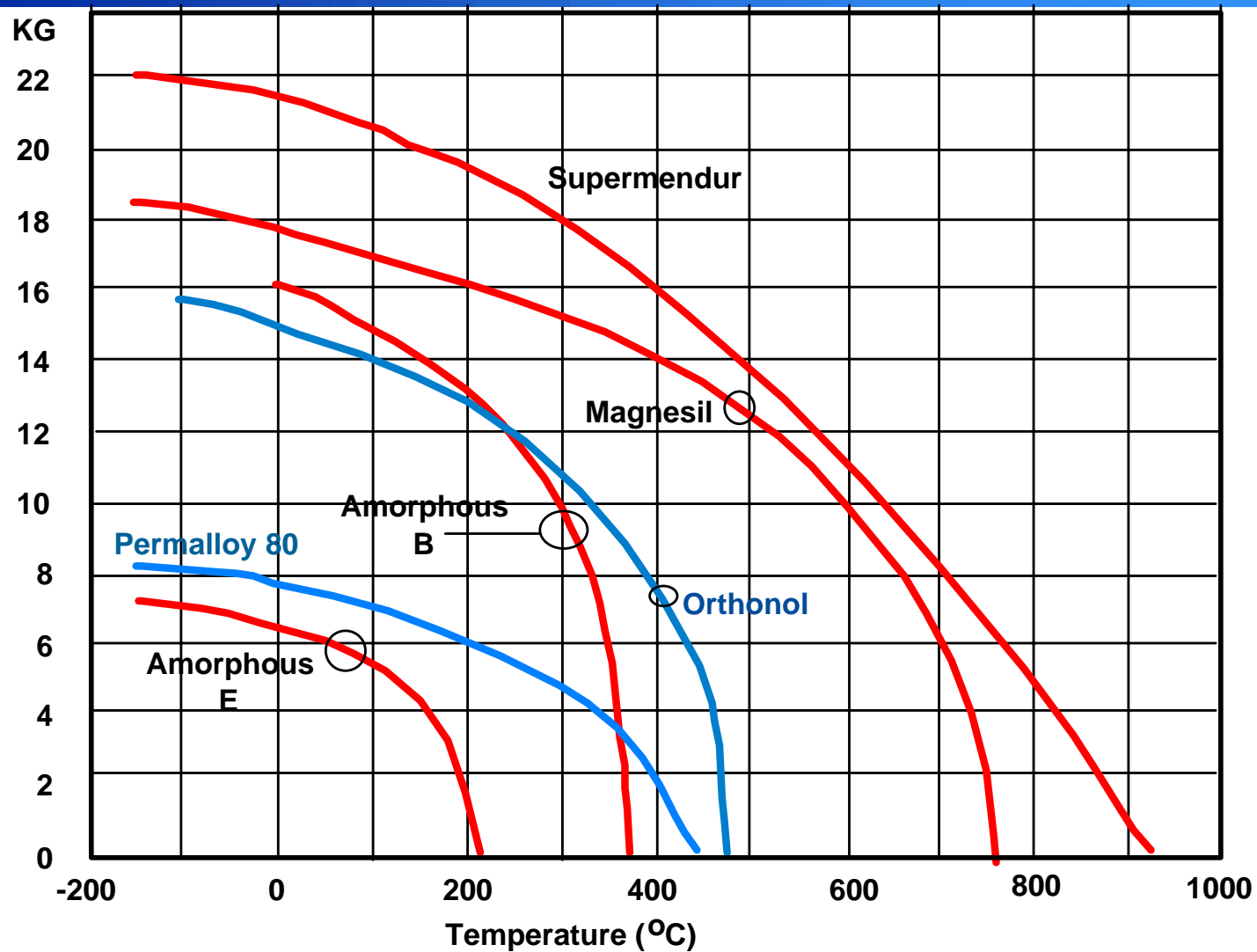


# Linear Devices

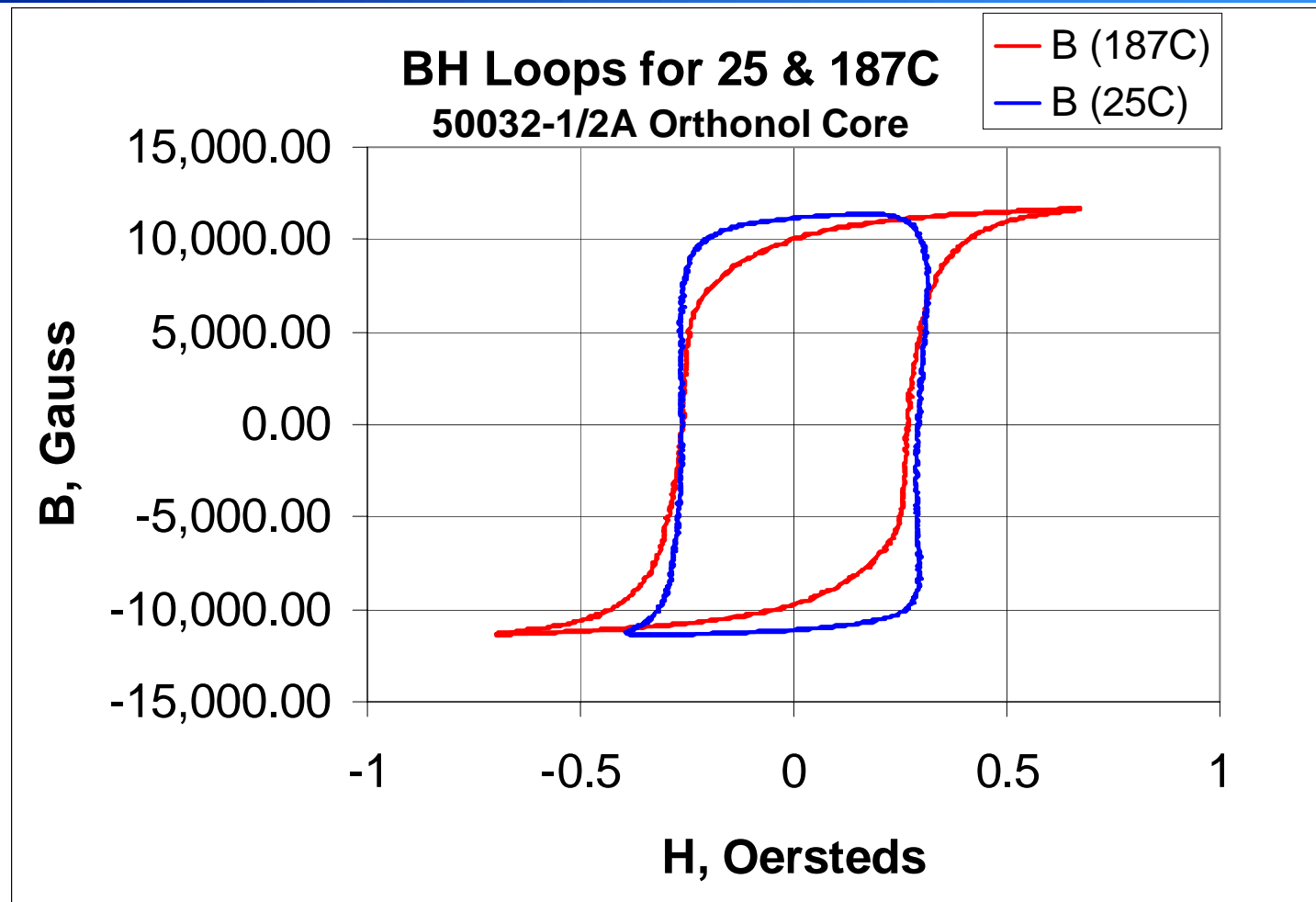
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- **Currently no Silicon Carbide devices exist for the following functions:**
  - Operational amplifier (test die at CREE in 1999)
  - Voltage Reference
  - Pulse Width Modulator
  - Controller
  - Logic
  - Memory
- **Current technology Workarounds**
  - Discrete amplifier
  - Discrete PWM
  - Discrete voltage reference

# Magnetic Materials (metal)

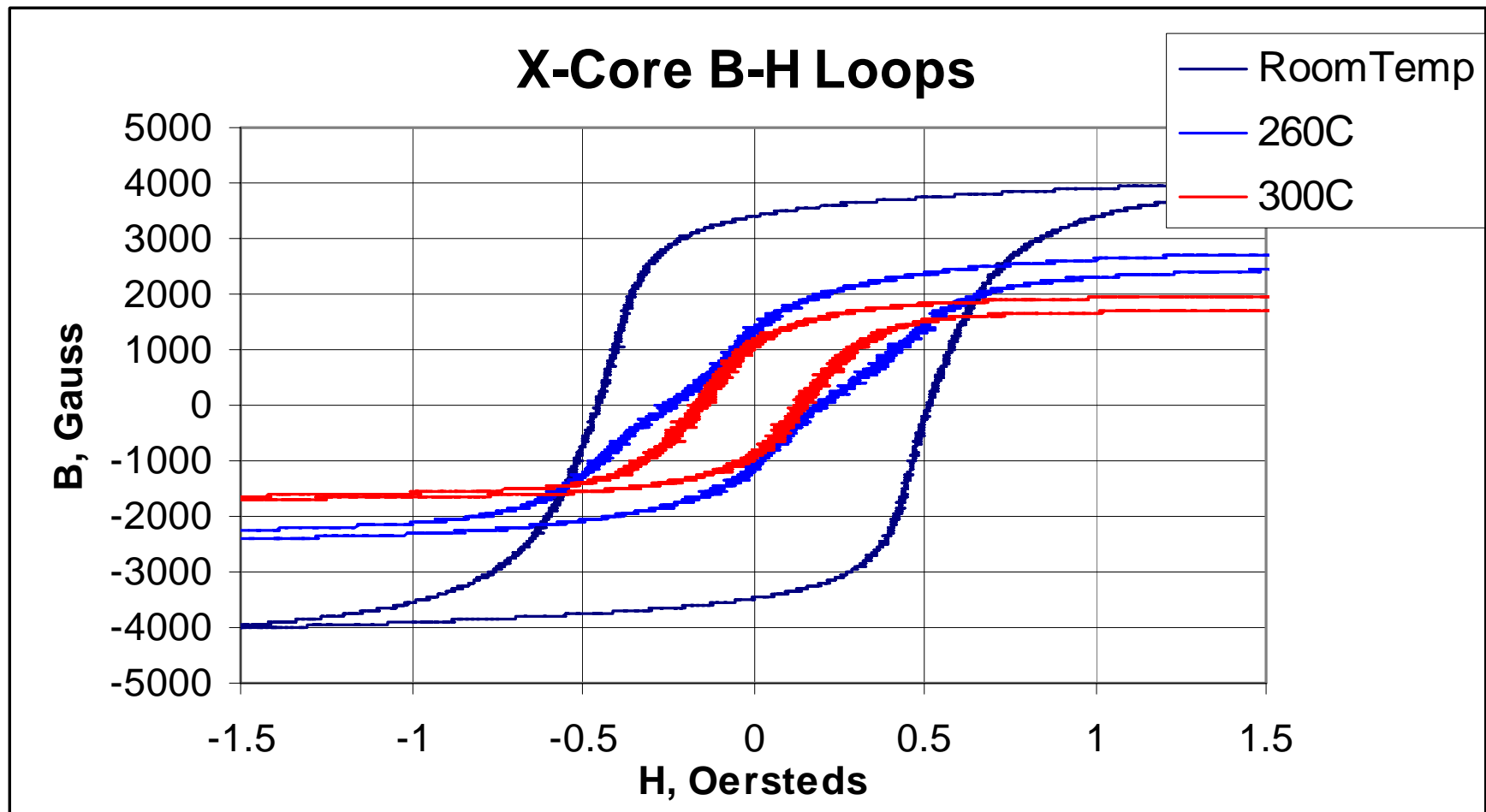


# Metal Tape Magnetic Materials





# Ferrite Magnetic Materials



# Capacitors

- Ceramic has the highest dielectric constant and temperature capability

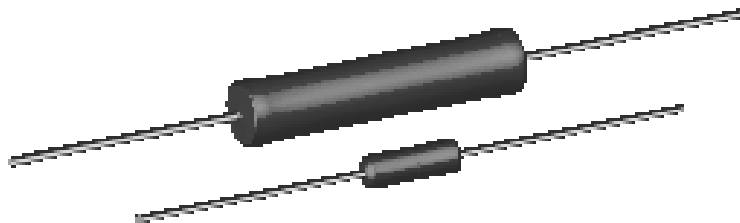
Material	Dielectric Constant	Capacitance ratio at 300C	Temperature Limit***
Glass	4	90%	>500C
Mica	5	90%	>500C
NPO ceramic	30	90%	>500C
X7R ceramic	2600	20%	>500C

\*\*\* with appropriate metalization and termination solution

# Resistors

- Metal film and wire wound resistors are usable at high temperature assuming adequate metalization and terminations
- Wire Wound
  - Large foot print for high values

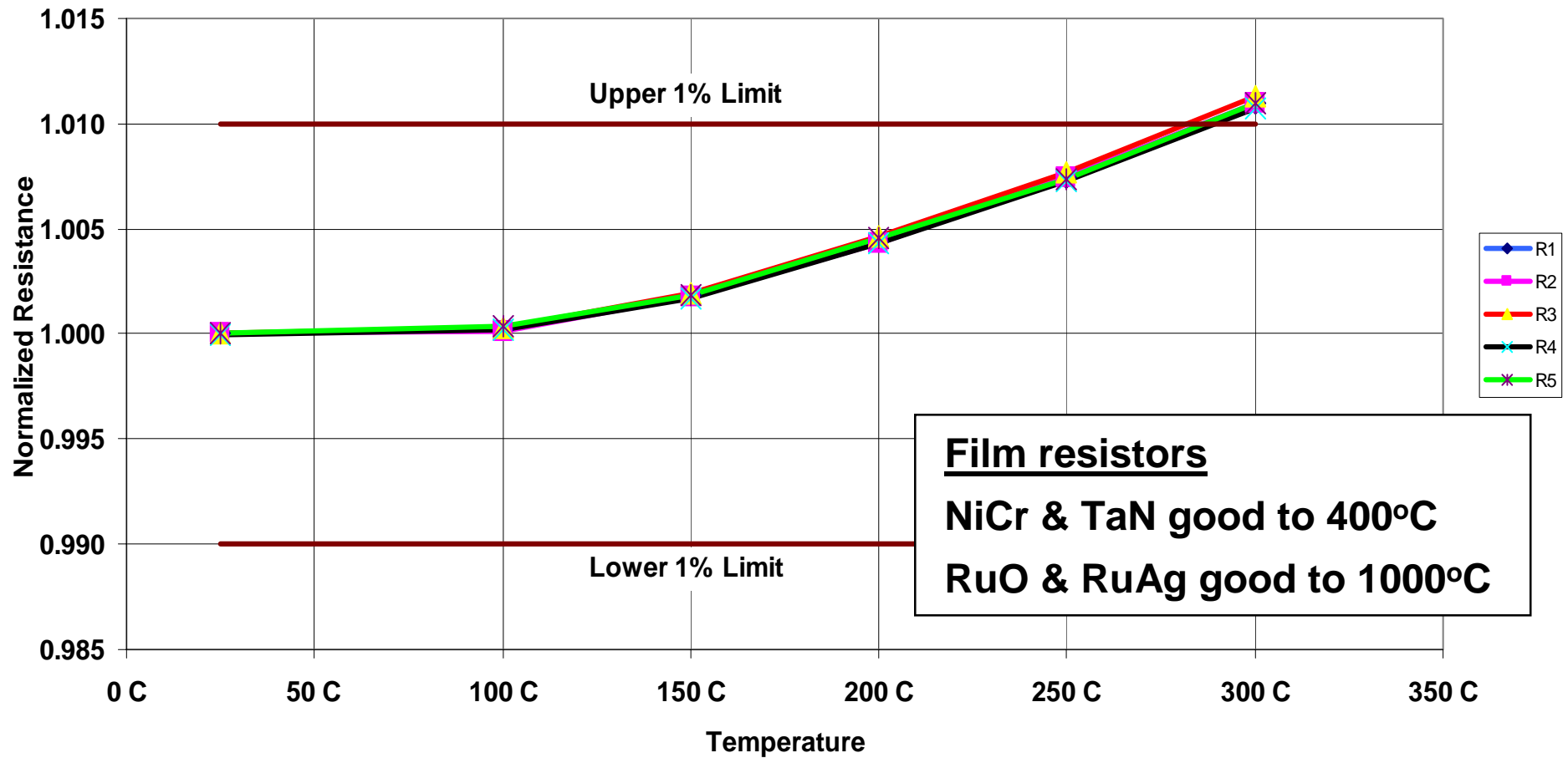
**Wirewound Resistors, Military, MIL-PRF-26 Qualified,  
Type RW, Precision Power, Silicone Coated** ▼



## **FEATURES**

- High temperature coating
- Complete welded construction
- Meets applicable requirements of MIL-PRF-26
- Available in non-inductive styles (type NS) with Aryton-Perry winding for lowest reactive components
- Excellent stability in operation

# Metal Film Resistors



# Printed Circuit Boards

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- **Need high Tg materials to get usable boards at high temperature**
  - Tglassification >> T-operate
- **Rogers has boards usable to less than 300C**
- **Possible use of materials for rocket combustion chambers to develop high temperature board material**
- ***Options:***
  - *Ceramic boards usable above 300C*
  - *Welded wire modules and brazing above 300C*

# Solder

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- Soldering is applicable for 300C+
  - Sn5%Pb
    - ◆ Melting point of 312 ° C
  - Au6%Si
    - ◆ Melting point of 373 ° C
  - Au12%Ge
    - ◆ Melting point of 356 ° C
- *Brazing or welding is required for 350C and above*

# Wire

- Insulation is key for dielectric strength and flexibility
- Transformer windings are the most difficult
  - Thin dielectric needed for high density
  - Tight turn radius stresses wire insulation
  - Thermal rise during operation elevates wire temperature
- Suitable wire types for 250C

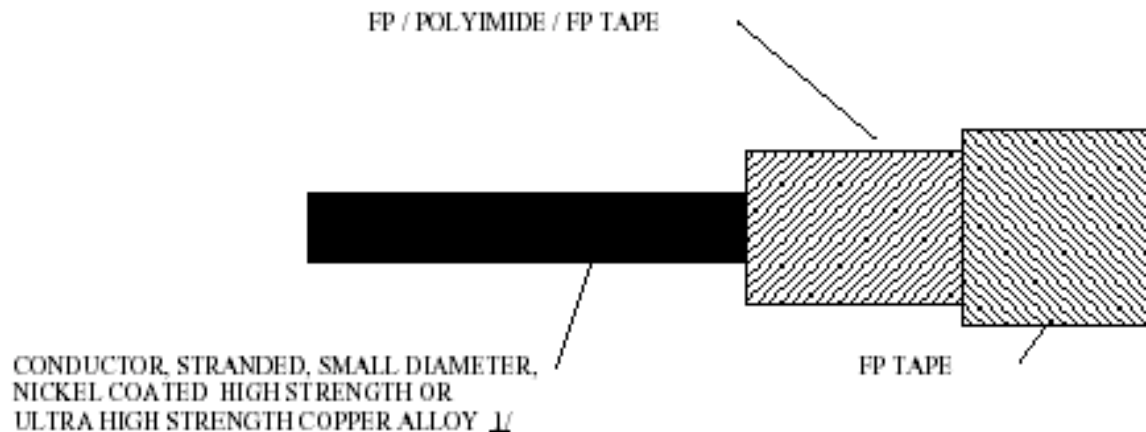
Wire	Spec	Cut Thru	Heat Shock	Properties
Polyamide	IEC 317-7	400C	240C	Good dielectric and mechanical properties

- *We need new types of insulation for temperatures above 300C*

# Cabling

- **Flexible insulation required for high temperature**

- Military Specification Sheet, Mil-W-22759
- Wire, electrical, polytetrafluoroethylene/polyimide insulated, light weight, nickel coated, high strength or ultra high strength copper alloy.
- *Rated at 260 °C, 600 V.*



- *We need new types of insulation for temperatures above 300C*



# Connectors

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- Contacts were exposed to 300 °C for 120 hours. The insertion and separation force tests were performed to determine affect on retention force. Tensile strength test was also conducted after thermal exposure test. The test data indicates that standard contact design is a candidate in high temperature connector construction.

# Current High Temperature Technology Maturity

	300C	400C+
• Switching devices	experimental	Possible (metalization issue)
■ Linear devices	none	Possible (metalization issue)
■ Magnetics	experimental	Development of thin tape
■ Capacitors	experimental	Possible (metalization issue)
■ Resistors	experimental	Possible (metalization issue)
■ Printed Circuit Board	experimental	(PrePreg issues and board)
■ Soldering/Welding	experimental	Workable
■ Wire	experimental	Difficult insulation problem
■ Cabling	experimental	Workable
■ Connectors	experimental	Possible

# Summary of High Temperature Component Technology for 300C+

	2003	2005	2007
■ Switching devices	experimental	Qualified	Flight
■ Linear devices	none	experimental	Qualified
■ Magnetics	Qualified	Flight	
■ Capacitors	experimental	Qualified	Flight
■ Resistors	experimental	Qualified	Flight
■ Printed Circuit Board	experimental	Qualified	Flight
■ Solder/welding	experimental	Qualified	Flight
■ Wire	experimental	experimental	
■ Connectors	experimental	Qualified	Flight